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BE IT KNOWN that I, **Bogie BOSCHA**, have invented certain new and  
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**A SYSTEM FOR AND A METHOD OF MANUFACTURING**

**PERSONAL GOLF PUTTERS**

of which the following is a complete specification

The PTO did not receive the following  
listed item(s) Transmittal

### CROSS REFERENCE TO A RELATED APPLICATION

This application is a continuation-in-part of patent application serial no. 09/920,529, filed on 08/01/2001.

This application is based on provisional patent application serial no. 60/473,317 06/04/2003, from which the priority is claimed.

This application is based on provisional patent application serial no. 60/442,548 01/27/2003, from which the priority is claimed.

### BACKGROUND OF THE INVENTION

The present invention relates to a system for and a method of manufacturing personal golf putters in accordance with individual swing characteristics of a golfer.

In the past five years, technology relating to the game of golf has evolved rapidly, with many different systems having been implemented for improving a golfer's performance and quality of the golf clubs utilized.

U.S. Pat. Nos. 4,063,259 and 4,375,887 disclose techniques for detecting golf club head position, and golf ball position, shortly after impact using

photoelectric means to trigger a flash so as to permit a photograph to be taken of the head and golf ball flight characteristics ( e.g. Launch angels) where data is collected using external monitoring cameras using standard golf club.

U.S. Pat. Nos. 6,565,448 B2, 5,342,054; 5,697,791; 5,486,001; 5,472,205; 5,249,967; 5,154,427; 5,111,410; and 4,713,686 disclose systems and methods for analyzing a golfer's swing, and providing feedback to the golfer based on images collected using external video cameras and standard golf clubs.

U.S. Pat. Nos. 5,501,463 and 5,575,719 disclose techniques using external cameras for detecting club head position shortly after impact using cameras capable of receiving light from multiple reflectors placed on the club head prior to the swing.

The other solution disclosed in U.S. patents nos. 2,416, 0942; 4,545,576; 4,713,686; 4,755,881; 4,860,096; 4,891,748; 5,111,410; 5,184,295; 5,210,603; 5, 333,061; 5,342,054; 5,441,256; 5,472,205 5,486,001; 5,501,463; 5,575,791; 5,591,091; 5,772,522; 5,797,805; 5,214,417; 5,823,387; 5,827,127; 5,864,960; 5,911,636; 5,951,410; 6,041,651; 6,565,448.

It is believed that the existing system and methods can be further improved.

### SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a system and a method of manufacturing personal golf putters, which avoids the disadvantages of the prior art.

In keeping with these objectives and with others which will become apparent hereinafter, one feature of the present invention resides, briefly stated, in a system for manufacturing a personal golf putter, comprising a putting surface with at least one hole into which a golfer putts balls; a putter with which the golfer hits the balls so as to put the balls into the hole; sensing means for sensing parameters of the putter during hitting the balls by the golfer to putt the balls into the hole; collecting and processing means for collecting and processing data corresponding to said sensed parameters; transmitting means for transmitting said data corresponding to the sensed parameters; computer means for receiving and processing said data; and design and manufacturing means for receiving the data from said computing means, determining final parameters of a personal putter based on said data, and making the personal putter with said parameters, said sensing means, said collecting and processing means, and said transmitting means being incorporated in said putter.

Another feature of the present invention resides, briefly stated, in a method for manufacturing a personal putter, comprising providing a putting surface with at least one hole into which a golfer puts balls; providing a putter with which the golfer hits the balls so as to put the balls into the hole; sensibly sensing means parameters of the putter during hitting the balls by the golfer to putt the balls into the hole; *collecting and processing data corresponding to the sensed parameters by collecting and processing means*; transmitting said data corresponding to the sensed parameters by transmitting means; receiving and processing said data by computer means; receiving the data from said computing means, determining parameters of a personal putter based on said data, and making the personal putter with said parameters by design and manufacturing means; and incorporating said sensing means, said collecting and processing means, and said transmitting means in said putter.

When the system is designed and the method is performed in accordance with the present invention, it is possible to analyze golfer's individual swing characteristics and to determine based on that analysis a suitable golf club configuration for the golfer with the use of the sensing and transmitting means which are incorporated in a normal golf putter with data related to the golfer's swing obtained in the most natural setting, i.e. unencumbered with cameras, lights and associated equipment, and to manufacture a personal golf putter exactly in accordance with personal characteristics of the golfer, by wirelessly taking the data from the golf putter in a remote computer device for collecting, computing and

analyzing the data and subsequent transmission of the data to a design and manufacturing facility which manufactures a personal golf putter in correspondence with personal characteristics of the golfer.

In accordance with one exemplary embodiment of the invention, the sensing means include at least one MEMS accelerometer sensor with at least one axis acceleration measuring means built on a single monolithic integrated circuit; the said sensing means is embedded in the golf head and shaft, and transmitting means include a microprocessor mounted in the shaft of the golf club and communicating wirelessly signals to the remote computer means.

In accordance with another embodiment of the present invention, the computer is connected to a display interface with means to display text images and graphics, and in addition means is included for analyzing the displayed graphics and text data of the golfer's swing. Displayed graphics can include putter club head acceleration /deceleration color coded line graph, putter path tracking line alongside acceleration line, lie and loft angles at address and at moment of impact with golf ball, color coded positions of the top of the grip, displaying information related to wrist applications and its effect in a putting stroke and ball speed factor.

In accordance with another embodiment of the present invention, the golf putter is electrically activated and the remote computer is also activated; and golfer's swing related data from the said golf club are automatically relayed to the

computer wirelessly and the feedback relayed to the computer wirelessly and the feedback relayed to the golfer is instantaneously displayed on a computer screen. The feedback displayed include the actual ball travel distance is measured and a target distance is entered in the database, and the golfer is ready to make a next swing. Each swing data is displayed and stored in the computer database until a full set of data is provided to the satisfaction of an instructor.

In accordance with another embodiment of the present invention, the golfer's data can be e-mailed to a remote location, in particular to a golf putter design and manufacturing center. The center can be provided with means for interpretation and analysis of the data and with means for providing recommendations for a specific configuration of the golf putter.

In accordance with still another embodiment of the present invention, in the design center computer can be provided with means for generating a machine language coded file for CNC machines with the use of mathematical models and with means to interface with the golfer's swing data, wherein the specification criteria of a personal golf putter include club head weight, lie and loft angles of the putter head and the overall lie and loft angles for the golf putter, and shaft length and shaft weight.

In accordance with still a further feature of the present invention, the computer at the design and manufacturing center is provided with means for

simulation, based on the golfer's swing data and the manufactured personal golf putter database, to test if the thusly manufactured golf putter will result in better or improved results of the golfer.

Also, means can be provided for confirming that the golf putter specifications are such that they provide a golfer with desired swing results, based on an analysis of the performance of a golf ball following impact with the manufactured personal golf putter, or on an analysis of the golfer's wrist movements during the golf swing.

The novel features which are considered as characteristic for the present invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its methods of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.



### BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 is a view showing a golfer with a golf putter, a golf ball, on a putting green and wirelessly connected pocket personal computer of the system and method in accordance with the present invention.

Fig 2 is view showing a flowchart of the system and method of the present invention;

Fig 3 is a view showing some features of a golf putter in accordance with the present invention; which is used in the inventive system and method;

Fig 3A is a cross sectional view showing sensor mounted in shaft in accordance with the present invention, which is used in the inventive system and method;

Fig 3B is a view showing the top of the golf putter with a light emitting diode and a speaker;

Fig 4 is a view illustrating a display showing acceleration and putter path color coded; color coded position of the grip handle in accordance with the present invention, which is used in the inventive system and method;

Fig 5 is a view illustrating a display showing lie and loft angles color coded; and ball speed factor text message in accordance with the present invention, which is used in the inventive system and method;

Fig 6a, 6b, 6c are views showing a configured putter head, a configured putter assembly correspondingly;

Fig 7a and 7b are views showing a putter open position and putter closed position at impact;

Fig 8 is a view showing graphical plots as shown on computer display of data received during implementing of the inventive method and system;

Fig 9 is a view illustrating sensing of corresponding parameters of a golfer's swing with a golf putter in accordance with the present invention;

Figure 10 is a view additionally illustrating sensing of corresponding golfer's parameters of a golf putter in accordance with the present invention; and

Figure 11a and 11b is a view schematically showing the inventive system in general representation.

## DETAILED DESCRIPTION OF THE INVENTION

The system and method in accordance with the present invention are illustrated in this application by showing how personal golf putter can be produced in accordance with the invention to be customized in accordance with golfer's characteristics. It is however to be understood that the term "golf putter" is used in a broad sense, and the same system and method can be used for manufacture of other personal clubs, such as drivers, irons, wedges, sand wedges and similar golf clubs.

As shown in FIG. 1, the system in accordance to the present invention has an initial putter, 300 with embedded electronic sensors with means to transmit and receive RF signals via Bluetooth module 360 having signal receiving and transmitting means, an artificial putting surface 10; and a pocket personal computer 60 with means to receive and transmit RF signals from the putter 300. A hole 30 in the putting surface 10 is the target for a golfer to roll ball into it. The putting surface is marked with concentric rings 14, placed about 5 feet apart for easy distance measuring. The system is suitable for either indoor or outdoor use. The putter 300 at the top of the grip 356 illuminates LED 366 or LCD display to show system status.

The means for sensing characteristics of the golf putter during swinging, the means for collecting and processing data corresponding to the sensed

characteristics, and means for transmitting corresponding data to a computer are incorporated in the golf putter.

The output of the putter 300 is wirelessly connected to the computer 60. The computer which can be formed a pocket PC; IPAQ 5400 series HP-Compaq computer with built-in integrated display 62 for reviewing visual images and text messages.

In one exemplary embodiment of the present invention, the computer 60 can include software for interacting with the putter data and control signals.

FIG. 2 shows a flow chart illustrating corresponding steps of the inventive method which is realized in this inventive system. As shown in FIG. 2, a golfer 5 has a need for custom fitted golf club (step 210) and he must be first be equipped with an initial-putter 300 (step 220). The golfer, 5 at a custom fitting golf pro shop is equipped with a golf putter 300 of known specification (aka initial Putter), identified as such with Serial number which will be electronically transmitted with each swing data, which includes data on: lie and loft angles, shaft length, putter club head weight, shaft weight. A golfer 5 hits series of golf balls from varying distances to the hole (step 230). All golf balls are of same make and specification. Each swing data are processed by the microprocessor MP to provide data corresponding to the sensed parameters, and then the data are electronically transmitted wirelessly to the computer, 60 for data collection, organization, and storage with appropriate

comments. The data are then transmitted by the computer 60 via internet connection to remote design and manufacturing center (step 240). At design center – swing data are analyzed using engineering workstations with software means to configure a specification for new putter head which is shown in fig 6a and a configured putter shaft which is shown in fig 6 b and a configured putter shaft which is shown in Figure 6c and the configured putter specification is realized (step 250). The specification includes club head weight, lie and loft angles, and ball striking surface characteristics and angular dimensions, shape of the sole, location of the center of gravity of the putter head assembled with the shaft. In step 260, a computer at the design and manufacturing center develops codes for the CNC machine which is employed to make the new personal configured putter to exact precision specification. In step 270, the putter is fitted with a shaft and lie and loft angles tuned in to realize a configured putter. In step 280, quality control verifies the new putter performance. In step 290, the thusly produced personal putter is shipped to golfer. On the shipping day it is possible to charge credit card to receive payments.

The putter system as disclosed contains an exemplary Putter 300 (Fig. 3) which has a putter head 320 with embedded sensors which include at least one gyro sensor <sup>340G</sup> 340, ~~xxx~~ and at least one linear accelerometer sensor <sup>340A</sup> 340, ~~xxx~~ – mounted on a printed circuit board 340 with an appropriate orientation with means to optimize signal strength and accuracy, with a connection means wire 354 to a main printed circuit board 352 provided with a microprocessor MP, with means for

connecting to a battery 370, and means to connect to a Bluetooth module 360 with an antenna 364 for wireless transmission to a computer the 60 shown in figure 1. The Sensors which are mounted on printed circuit board 350 are dual x and y monolithic sensors placed horizontally to the earth E plane and x/y orientation placed with respect to putting stroke direction for measuring the lie and loft angles as well as providing a system control signal for the microprocessor . The microprocessor collect and processes data related to parameters sensed by the sensors. The putter 300 has a rubber grip with an embedded multifunctional momentary switch 358 and a light emitting diode 366 placed on top of the grip 355. The light emitting diode 366 can also be replaced with LCD displays with alpha-numeric display characters for information related to controls and putter system status. By depressing and holding the switch for programmed time enables the golfer to select various control functions of the putter system.

The switch 360 is used for turning on the electronic system of the initial golf putter (for example by pushing the switch and letting it go), for activating of sensing, data collecting and processing, and transmitting means (for example by further pushing the switch and letting it go), for resetting the electronic system in the event of malfunction (for example by pressing and holding the switch for 10 sec), for loading a new software into the microprocessor which collects and processes data and acts as a controller for controlling the system through the software (for example, by pressing and holding the switch for 30 sec).

The light emitting diode 366 in correspondence with the above-listed modes of the switch 366a, for example flashes for 15 sec, comes on and stays on for 2 sec and then turns off, flashes very quickly 15 cycles per 1 sec, flashes at 60 cycles per sec., correspondingly.

A speaker 366a (Fig. 3b) provides voice messages corresponding to the above listed 4 modes, for example "on", "ready", "reset", "program".

A screw cap 367 is provided for closing a compartment for the battery.

The putter head 320 includes a hosel 310, a back surface 380, a heel 314 and toe 317, a sole 330, and a front strike face 325. The front strike face 325 is flat, and is set at approximately 4 degree loft 327 with respect to a line perpendicular to the sole 330. The putter head 320 and a putter shaft 304 are configured such that the putter 300 has a 74.degree. lie 390. The said lie angle, 390 can range from 60 to 85 degrees as a part of custom fitting.

Fig 3A shows a cross section of a dual axis linear accelerometer sensor assembly 350 mounted in the putter shaft 304. The sensor assembly comprises of a dual axis linear accelerometer sensor 340 mounted with its flat surface on a flat surface provided on a shaft insert 343 and angled to the shafts lie angle 390 with the horizontal surface or the earth plane O-ring <sup>347</sup>~~343~~ seals the inserts 343 in the interior of the shaft. In accordance to the invention, the position

of the sensitive dual axis of the sensors must be approximately orthogonal 341 to the gravity vector force  $g$ . The Y axis 345 of the sensor is mounted such that it's pointing in the direction of the ball travel when hit squarely and it is orthogonal to the gravity  $g$  vector force. The x axis is positioned orthogonal to the y axis and the  $g$  vector force. The sensor 340 is mounted on a conventional printed circuit board 342 with electronic components 344 on both sides of the board manufactured using conventional surface mount technology practiced in the electronic industry. The mechanical pin 348 is press fit to hold the main printed circuit board 352 to the mount 343.

Fig 4 shows an interface displays output from computer 60 based on golf swing data received from the putter 300 with the means to transmit and receive data wirelessly 360, and received by computer 60 with means to receive and transmit data wirelessly 64 (antenna). The computer 60 has the means to compute the data and display multi-color coded acceleration data 400 of the putter head club and putter path of the club head 420 (color yellow ) along the putter head length of travel  $L$ , of the putter head of a known specification, initial putter. The color for the acceleration is green 406; black 404 shows constant speed; and red 402 shows deceleration of the putter head. The display shows ball speed factor 410 (text message in yellow color), which is the measured force by which the embedded accelerometer sensors measure impulse magnitude at impact of club head and the golf ball at rest. The ball speed factor is a derived measure of the impulse force magnitude and is correlated to stimp measure of the putting greens. The golf ball



goes from rest state to rolling state. The acceleration bar 400 is multi-color coded; the black 404 shows the zone where putter stroke is at a constant speed, zero acceleration. The red color 402 denotes deceleration of the putter head. The green color 406 denotes accelerating zone of the putter head. The radio buttons, 450, are control buttons for the computer software. The red elliptical element 444 shows the position of the golf club shaft top part of the grip position at address, and it shows blue color 442 for the handle position at the moment of impact of the club head with the ball. In this example, it is a forward press, term used by golfers, by forward pressing the loft angled is de-lofted resulting in improper rolling of the golf ball and possible loss of direction control and distance the golf ball will roll.

In Fig 4 the ball speed factor 410, is the computed force measured at impact of the putter club head 320 with sensor 340 and the golf ball, B (fig 3), based on the formula,  $F = ma$ , where F is Force, m is Mass of the putter head, and a is the acceleration of the putter head as measured by sensor 340 in figure 3. Using tabulated data of ball speed factor and the distances balls rolled for corresponding hits, the computer model with means of modeling, mathematical formulas related to conservation of momentum, impulse energies, and vector analysis are used to determine putter head mass, that would be suitable to a particular golfer's swing characteristics. The results can be virtually tested on the computer to optimize the configuration of the putter.

Fig 5 shows interface displays output from computer 60 based on golf swing data received from the Putter 300 with the means to transmit and receive data wirelessly 360, and received by computer 60 with means to receive and transmit data wirelessly 64 (antenna). The computer 60 has the means to compute the data and display color coded lie, 500( gray), 520(green) and loft, 510(green), 540(green) and text data( yellow) 502, 504, 506, and 508 of the putter. The lie and loft displays can be displayed at any selected points, for example 550 along the length of putter travel, length L,. The putter images 500 and 510 are position of the shaft at address with respect to lie angle 500, 0 deg 502 in this example; and loft 510, minus 1 deg 504 in this example. This data based on several swings can be averaged and general putting tendency can be determined using law of averages and statistical modeling to determine a configured putter specification that would improve the putting accuracy and consistency. The position of the putter grip, top of the handle is shown with an elliptical shape 552, which is color coded blue designating the position at the moment of ball hit. The red color 554 designates the position of the handle at address.

Fig 6 A shows a putter head with a newly modeled specification. The putter head 610 has a defined weight, lie and loft angles and hosel hole position, 620, with hole center 620' with respect to the putter striking surface 325 to allow for off-sets specifically tailored to golfer's particular characteristic.

Fig 6 B shows a putter shaft 650 of specific length 660 and 660' and weight, lie angle, 640

Fig 6C shows putter assembly 670 comprising a configured putter club head 610' fig 6 A and a configured putter shaft 650' fig 6B. and the overall all putter lie angle 640' that is configured to the golfer's specific needs with shaft length L' 660' or L 660. The putter off set can also be designed into the shaft with appropriate bends incorporated in the it.

Fig7.a shows the putter head 320 in closed position angle 710 at the moment of impact with the golf ball B and the arrow 720 pointing the direction the ball will travel as a result of the closed clubface hit. Fig7 b shows the putter head 320 in open position angle, 730 at the moment of impact with the golf ball B and the arrow 740 pointing the direction ball will travel as a result of the closed clubface hit. The gyro sensors mounted on sensor assembly 340, 340G( fig10) in accordance with the invention determine precise angles at which the putter face 325 makes contact with the ball B at impact.

Table I includes Z,X and Y axes data set as transmitted by the putter 300 of an actual swing.

Fig 8 is a graphical presentation of the data set in table I . The Z axis shows acceleration of the putter head as it moves forward towards striking the ball.

The beginning of the forward stroke is at time 801 first minimum voltage of the back stroke. v1 and v2 are examples of acceleration zone.

Figure 9 and 9A illustrates the basic concept of measuring lie and loft 92 and 92' angles of the putter head attached to shaft 304 of length L. The sensor assembly printed circuit board 350 is mounted inside the hole of the shaft near the grip area to minimize the dynamic signal component to the swing data and obtain better and more accurate handle position 96 data from the sensors 350A, in x and y axis 350A-X and 350A-Y respectively. The travel range 90 of interest for loft measure is less than 30 degrees. The lie angle 350A-X measure is orthogonal to the loft angle 350A-Y, similar to that of the loft angle measurement. The length of the putter shaft adds to sensitivity of angle measure.

Figure 10 illustrates the basic concept of measuring the acceleration and angular rotation of the putter head. The sensor assembly printed circuit board comprises of at least one linear accelerometer sensor 340A and one GYRO sensor 340G. The linear accelerometer sensor 340A is a dual axis sensor, axis X and axis Z, 340A-X and 340A-Z respectively measure acceleration and deceleration component of the club head. The GYRO sensor, 340G measures the rotational component of the club head movement about the center of putter shaft 304 axis. The sensor assembly 340 is electrically connected with wire transmitting means 354. The putter shaft hosel 310 hold the shaft in position rigidly to the putter head. The sensor assembly is mounted so that the sensitive axis 340A and 340G is orthogonal

## *Insert 1*

; and 128 voice interface that enables audio instructional comments being directed to the golfer. For example, in figure 4 the forward process 442 of the club handle and de-lofting of the clubface 325 at the moment of the ball impact, the audio instruction comment would highlighting that fact with comments. Instructional comments would be provided by well know and industry highly recognized professional instructors in the game of golf. Likewise all aspect of the putting stroke as measured can be analyzed by the computer and analysis provided with audio comments.

to the earth surface with gravity force  $g$  component orthogonal to the sensor sensitive axis 340A-X and 340A-Y and 340G.

Figure 11A, 110 illustrates the putter 300 system block diagram which comprise the sensor assembly in the putter head 119, which is electrically connected to the mixed signal microprocessor 116. The sensor assembly in the handle 118 is also connected electrically to the mixed signal microprocessor 116 which is connected to the power source 111 and to the transmission and receiving means 112 with antenna 114. The multifunctional switch 113 is mounted on the handle embedded in the grip to provide control to system. Figure 11B illustrates the remote computer part of the system wirelessly connected to pocket personal computer 122 which has a display interface 120 to provide instantaneous visual feedback to the golfer and computer 122 has the interface to enable connection to conventional telephone lines for internet connectivity to design center 124 and beyond; *and also ..... in sect ① p. 21a*

The golfer 5 is equipped with the Putter 300 of known specifications which is an initial putter. As explained, putting results are used in custom fitting of a personal putter in accordance with the golfer's individual swing characteristics.

For example, it has been determined that, putter with strike face 325 has a 4.degree. loft to impart a perfect roll on the golf ball at impact enabling the golfer to better control ball direction of travel and the ball speed factor (fig 4, 410 ).

This assumes that the golfer managed a perfect lie and loft angles, that is the top of the grip 442 at moment of impact with the golf ball was superimposed on the reference, R.

The system determines a particular golfer's 5 forward press tendency (see fig 4, 442 ) which, one skilled in the art will understand, is a situation wherein the golfer 5 allows his hands/grip, 355 to travel ahead of the club striking face 325, during the putting stroke and at the moment of the ball hit. i.e de-lofting the club head striking surface 325. Thus, at impact, through imparted tangential forces, the golf ball will be pushed into the putting surface, resulting in loss of direction and distance control. This downward action on the ball, by de -lofted putter striking surface 325, causes the opposite reaction and the golf ball jumps off of the putting surface. This jumping out results in loss of direction and loss of energy imparted in striking the ball, thus loss of control and accuracy. Therefore, in custom configuration of the putter, the design would have built in loft angle to compensate for the forward press natural tendencies of the golfer 5, so that the effective loft angle of the strike surface 325 is 4 degrees at the moment of club head face 325 impacts with the ball 20 resulting in perfect roll of the ball and hence controlling the ball speed/ distance relation and ball's direction.

In another example, the system determines a particular golfer's 5 rearward press tendency (see fig 5, 552 ) which, one skilled in the art will understand, is a situation wherein the golfer allows his hands/grip, 355 to lag behind

of the club striking face 325, during the putting stroke and at the moment of the ball hit. The resulting tangential force on the ball will cause the ball to be lifted up and off the putting surface in 10, fig 1 and slight undesirable back spin will be imparted on golf ball 20, causing the golf ball 20 to "check-up" or "push-up " upon impact with the putting surface 325, again resulting in loss of direction and distance control, as this upward action on the ball, by increased lofted putter striking surface causes the ball to become airborne for a moment and the inertial forces on the ball are back spinning causing the ball to bounce on the putting surface 10, and skidding before the ball's back spinning inertial forces are neutralized to zero by frictional forces of the putting surface. 10 before the ball begins to resumes forward roll in the direction of the hole. This skidding and ball check-up results in loss of direction and loss of energy imparted in striking the ball, thus loss of control and accuracy. Therefore, in custom configuration of the putter, the design would have built in loft angle to compensate for the rearward press natural tendencies of the golfer 5, so that the effective loft angle of the strike surface 325 is 4 degrees at the moment of club head face 325 impacts with the ball 20 resulting in perfect roll of the ball and hence controlling the ball speed/ distance relation and ball's direction.

In the event the data collected on a golfer shows such type of inherent natural behavior, as described above; (either forward press tendency, fig 4, 442; or rearward press tendency, fig 5, 552 by the golfer) then the computer modeling will take this information in to account and result in a custom design CNC machined personal putter and shaft combination that will account for this deviation in angular



lofts, therefore resulting in an effective 4 degree loft at moment of impact with the golf ball resulting in consistent forward roll of the ball and distance control.

Similarly, loss of energy and direction results in deviations resulting from the lie angles and open or close positions of the putter striking front face at impact. By analyzing the data, it is determined that the golfer 5 is slicing or drawing the golf ball at impact.

It is also determined if the golfer is keeping the club face square through impact or, alternatively, whether the golfer is opening or closing the club face through impact.. This is combination of information available in the putter path 420 fig 4, forward 442 fig 4 or reward press 552, fig 5 and open angle 710 fig 7 or closed 720 fig 7 as measured by gyro sensors built into the PC board 340 fig 3.

For a right handed golfer, "slicing" refers to those situations wherein the ball is imparted with a force resulting in clockwise spin rotation about the balls center axis, when viewed from the golfer's perspective, upon impact a sliced putt may result when the putting stroke starts outside the proper swing plane, and then proceeds to move towards the inside of the swing plane upon impact with golf ball B fig 7A. For a right handed golfer, "drawing" refers to those situations wherein the ball is imparted with force resulting in counter-clockwise spin rotation about the balls center axis, when viewed from the golfer's perspective, upon impact a drawn putt may result when the putting stroke starts inside the proper swing plane, and then

proceeds to move towards to the outside of the swing plane upon impact with the golf ball , B fig 7B. Slicing or drawing of the golf ball fig 7a and 7B during the putting stroke is undesirable, as it results in a loss of putting accuracy, both in terms of direction and in terms of distance and ball speed control. A failure to keep the club face square through impact is undesirable for these same reasons.

In the computer the golfer's data are analyzed and golfer's preferred tendencies during the putting stroke are determined. Based on these conclusions, the specifications for a configured putter, the offsets – i.e. strike face to putter shaft relationship is set. The putter shaft center is either moved forward and backward 610, fig 6a with respect to the referenced putter center for the configured personal putter. Neutral or aggressive hand action is information extracted from the putter path 420, data and all other data related to effects of the hand grip position 442, and 552 at impact, and combined with other data to obtain an overall grasp of the putting stroke. The final personal putter is configured to fit the golfer 5 so that natural swing tendencies specific to individuals are maintained resulting in effective putting.

Depending on the desired means for storing data obtained from Putter 300, computer 60, may additionally be wirelessly connected to other peripheral devices such as video cassette recorder (VCR), a DVD player, or a CD RW ROM (read and write) drive . The computer 60 includes a software for converting digital data in meaningful images and text messages formed from data collected from the VisVia Putter as shown in Figure 4 and figure 5.

Once all the data has been collected and transmitted, or e-mailed to design center , in step 240, figure 2, a computerized design model with mathematical algorithms using engineering workstation computer is employed to perform swing related analysis. The engineering workstation is equipped with software means to custom design putter parts and assembly process: club head, shaft and shaft installation. At the output there are provided CNC related machine codes for milling a precision putter head out of a block of metal, or forged metal pre-form or pre-form molded part, or a die caste part, with precise lie, and loft angles, weight, club-face-finish and also the final shaft lie angles and required off-sets and shaft weight and shaft length. The machine process is not limited to CNC machines but is adaptable to other processes as well.

The resulting custom designed putter is then computer tested using the same putting strokes to determine if the newly configured putter would result in improved results. Similarly several computer iterations can be performed to realize optimum putter design for the golfer. The putter is manufactured and tested to verify the performance and mailed to golfer's ship to address.

This is an efficient process and lends to having professional golf teachers and others in the field of golf all around the world to have the ability with the invented apparatus to collect data form golfers and have at least one design center supply custom configured golf clubs.

Additional details for determination of corresponding characteristics and calculations of corresponding data are presented herein below.

How to measure accelerations of Putter head and ball speed factor: ( fig 4, 410, 402, 400, 404)

MEMS accelerometers, manufactured by, for example, Analog Devices, Massachusetts company, model numbers ADXL 202, ADXL 210 ( or other similar parts manufactured by other companies ) can be used as liner acceleration or force measuring sensors for sensing the movement of the putter head. In this invention, Analog Devices parts, ADXL 210, 202, 260, and 183 were used.

There are two forces; one is gravity force which is a constant, and second force is the variable force which changes in the sensor mounted in the club head as the golf club moves. The changing variable force is monitored continually monitored with respect to the gravity force constant. Motion as influenced by gravity forces which for the invention is constant as all the motions are done on the earth's surface.

The sensor 340 assembly comprise a linear dual axis accelerometer sensor 340A and Gyro sensor 340G, positioned in the clubhead, figure 3 and figure 10, so that at least one axis, Z – Axis, 340AZ for the linear accelerometer 340A is aligned along and parallel to the axis of travel of the club head, F vector and that this

axis is perpendicular to the earth's gravity vector,  $g$ . It is also perpendicular to the putter face 325 fig 3. Club head 320 movement gravity forces " $g$ " are detected by the sensor and converted into electrical signals. The electrical signals, analog in characteristic are connected to and transmitted to mixed signal microprocessor's analog to digital input ports and digitized for the microprocessor protocol. The digitized signals will be transmitted to the computer 60 for processing. Similarly, data from X axis, 340A-X is collected and processed for use in putter path measurements and compliment data from other axis to form a true 3-D image of the dynamics of the putter.

Table I, Z axis, column A is representative of the data collected for a putting stroke from this sensor 340A-Z This data, velocity-time graph is plotted, example of an actual swing is shown on fig 8 , Z axis. The voltages directly correlate to velocity factor " $v$ " as per Analog Devices component ADXL specification. The " $v$ " values are then used in mathematical formulas concepts discussed below. The second axis of the dual sensor 340A, 340A-X data is not shown here, this axis is perpendicular to the, Z axis of travel of the putter head, vector F. The 340A-X axis data can be used can be used for putter path and compliment data from other axis to form a true 3-D image of the dynamics of the putter.

The data form the gyro sensor 340G is not displayed but it is similar to the 340A, and in this invention the Gyro sensor data is to measure angular rate

of change of the putter head about the shaft 304 axis of rotation. In this invention, it is important to know the position of the putter face 325 fig 3 at the moment of ball hit, ie Putter face angular orientation at the moment of contact with the ball.

Distance traveled by the putter head on the back stroke and forward stroke at any interval can be calculated from the velocity-time graph data base for the Z-axis ( sensor 340AZ). From this data, acceleration factors are calculated; by definition, "a" acceleration is change in velocity over change in time.

Distance traveled over finite time 0.008 second interval as used in this invention is only an example, is calculated from the collected data obtained related to velocity over that time period. All calculated distances are summed up on the back stroke and like wise all forward moving putter stroke distances are calculated and summed.

This back stroke and forward stroke distance verses impulse force imparted to the golf ball at rest is one of the determining factor in putter weight measure in custom fitting of the golf club. It is a measure of how efficient a golfer is in putting, in controlling ball speed and direction, which translates into accuracy. Shorter strokes result in higher accuracy. Stroke distances create momentum, which directly corresponds to ball speed and distance it rolls on the putting surface. This however needs to be optimized, and this invention can assist golfers to do just that

optimization process. Or golfers can train to develop sensitivities to distances and hands grip force applied to the putter.

Forces can be measured from the data base by using well known Newton's Law of Motion.

First law – has to do with mass of the putter head. Mass of a body is a measure of its inertia. For all practical purposes for the determining the cause and effect in golf, we will consider mass to be same as weight of the putter head, weight of the shaft and off course the total weight. Typically, putter weight ranges from 300 to 425 grams.

Second law - Force is equal to rate of change of momentum. The rate of change of momentum of a body is proportional to the resultant force applied and occurs in the direction of the force. The momentum of a putter head of constant mass "m" moving with velocity "v " by definition in physics is a product of the two, "mv". (  $M = mv$  ) And as this movement of the putter head is caused by a golfer applying the necessary force by holding on to the putter shaft at the grip location, therefore resulting in change of momentum, we can represent this as mv1 and mv2 and as this change is taking over a finite time change, we can then calculate force. As Force is proportionate to the difference in momentum 1 and momentum 2 over time "t " {  $F = (mv_2 - mv_1) / t$  }

Grip pressure applied at the moment of impact with the ball plays a very significant role on the impulse force imparted to the ball. Grip pressure analysis can be performed from the data and comments can be conveyed to the golfer via computer generated voice or text messages on the display interface.

If we make the time factor very small, for example one microsecond, for the application of golf and for this invention, Force impulse can be calculated- that is a very short duration force applied to an object, like a golf ball at rest. When the said golf ball B is hit with putter head 320 fig 3 with a mass of factor 7 more than the golf ball. (Putter Head typically weighs 340 grams and the golf ball weighs 46 grams) This factor of seven mass differentials between the golf ball and the putter head makes these calculations even more accurate approximation and very repeatable. Repeatability is important for this invention application as to convey consistent feedback to the golfer.

The well known laws of conservation of momentum is applied in this invention. And knowing the mass of the golf ball and the mass of the putter head, one can calculate the rest state( zero velocity  $V = 0$  ) to instantaneous velocity  $V_i$  of the golf ball when hit. This is the ball speed factor calculation. ( $M_p V_p = M_g V_g$ ),  $M_p$  is Putter head mass,  $V_p$  is Putter head velocity and  $M_g$  is golf ball mass, and  $V_g$  is golf-ball instantaneous velocity. Mass is equal to weight for all calculations for this invention.



Kinetic Energy is the energy putter head has because it has motion, or is in motion during the forward putting stroke, Kinetic energy,  $E_k$ , of a putter moving at velocity  $v$ , is equal to  $\frac{1}{2} Mv^2$ . Kinetic energy is another methodology for calculating ball speed factor.

Consistent grip pressure is necessary to impart consistent force to the golf ball at rest assuming other factors such as acceleration and putter weight being constant and consistent. Impulse Force measure to gather with club head velocity and putter weight can provide feedback on the grip pressure.

#### How to Measure of Lie and loft and angles –

MEMS accelerometers, parts manufactured by Analog Devices, part no ADXL202 and ADXL 210 and other similar parts manufactured by other companies in the trade is used in this invention to take advantage of the gravity as an input vector to determine the position of the golf club-grip in free space. As the golf grip is part of the shaft, which is rigid and which is connected to the putter head, by measuring the position of the grip in free space the putter face position with respect to the vertical plane is determined with good resolution and repeatability, which conveniently happens to be the same as gravity vector. This applies for both the loft and lie angles.

In our golf application, fig 9, the dual axis accelerometer, x and y sensitive axis, 350A, fig 3, and fig 9 is placed perpendicular, to the earth's gravity vector, g. In this orientation the sensor 350A is most sensitive to changes in tilt in any direction as the axis X and Y will be affected. And it happens by design the tilt measures to be most linear in the first 15 degrees tilt. In this invention the range of interest, 90 fig 9 is within first plus or minus ten degrees, 92. The linearity within first 10 degrees is very good and hence enables for very accurate and repeatable readings. The putter has tilt resolution of less than 0.1 degree as in this invention the putter shaft, 304 fig 3, 36 inches length typical comes in to play. At position 96, when sensor's sensitive axis is perpendicular to that of the gravity vector g, the sensors are most sensitive to tilt. i.e. minute tilt angle change will result in maximum electrical signal change.

Hence in the putter, the dual axis sensor' both sensitive axis is positioned in the putter handle, so that the sensor's sensitive axis are perpendicular to the earth's gravity vector. And since the X and Y axis of the sensor are orthogonal to each other by positioning the sensor in the handle so the X axis is oriented to measure the lie and angles and the Y axis is positioned to measure the loft angles

Fig 8 shows the plots of data from Table I columns B, is for X axis, and Column C is for Y axis.

The data is used in mathematical calculations where the "mg" ( milli g ) experienced by the sensors are converted in to electrical signals which in turn are used to determine the tilt angle. This information is then displayed on the display of the computer.

#### How to measure or determine the Putter Path ?

Determination of the Putter path 420 is performed by use of X and Y tilt angles over time base from the sensors 350A in the putter shaft, 304 and the position of the putter head as measured by sensor 340 as per distance traveled in the putter head 320 also over the same time base. These three points over time base provides the means to determine mathematically the exact position of the putter head along the forward and backward stroke of the putter head in the line of the putter path and its lie and loft angles at any given time during the putting stroke.

#### Sample Calculations for measure of Lie or Loft angles: Fig 9 reference:

Sensor 350A is positioned in the shaft and its sensitive axis X and Y is perpendicular to the earth's gravity vector.

At 0 g = 90 degrees grip handle position 96 fig 9. And at 0 degrees the sensor output is at 1.g, or 1000 mg( milli g's ). This corresponds to 11.11 mg's per degree change in the grip handle position along the circle radius, L inches. Typically

the shaft length is 36 inches long. The longer the shaft better is the measuring resolution.

The circumference of the grip travel with putter sole 97 as a pivot point is simply  $2\pi R$ ,  $\pi = 3.174$ ,  $R = 36$  inches. And since, we are only concerned over 90 degree angular travel, the quarter circumference,  $\pi/2 \times 36 = 57.132$  inches. This comes to 0.6348 inches per degree change in the grip handle position.. Per analog Devices specification the sensor out put as per inventions positioning in the shaft, results in 17.5 mg out put per degree change. The system design per invention is able to measure 0.1 degree resolution with good repeatability.

The major new feature of the present invention is that the sensing means, the data collecting and processing means, and the data transmitting means are incorporated in the initial putter. How these means are mounted on and connected to the initial putter is not germane to the invention, and conventional techniques are possible.

The sensor assembly can be mounted inside the putter positioned just below the hosel 310. The assembly is inserted from the bottom side (sole 330) of the putter end and sealed with RTV and epoxies with a thin metal plate for fine finish.

In accordance with the present invention also a training golf putter is produced and used. The training golf putter is designed exactly as the final personal

putter, and in addition has the sensing means, the data collecting and processing means, and the transmitting means incorporated in it. A player uses the training putter to strike the ball and to analyze his performance with the use of a computer with the display, etc., as in the case of using of the initial putter.

It will be understood that each of the elements described above, or two or more together, may also find useful application in other types of methods and constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a system for and a method of manufacturing personal golf putters, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.